(19) JAPANESE PATENT OFFICE

BB

PATENT ABSTRACTS OF JAPAN

(11) Publication number: **10027539 A**

(43) Date of publication of application: **27.01.98**

(51) Int. Cl **H01J 1/30**
G09G 3/22

(21) Application number: **08180377**

(22) Date of filing: **10.07.96**

(71) Applicant: **SHARP CORP**

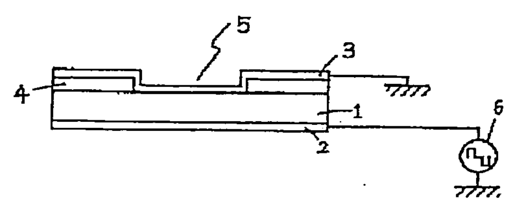
(72) Inventor: **OTANI NOBORU**

(54) FERROELECTRIC COLD CATHODE AND ITS DRIVING METHOD

(57) Abstract:

PROBLEM TO BE SOLVED: To make controllable the emission area and amount of electrons emitted and the spread of the emitted electrons by providing a portion where an insulating film intervenes between a ferroelectric and an upper electrode and a portion where the ferroelectric makes contact with the upper electrode to form an electron emitting window.

SOLUTION: This ferroelectric cold cathode has lower and upper electrodes 2, 3 placed respectively at the bottom and top of a ferroelectric 1, and has between the ferroelectric 1 and the electrode 3 a portion where an insulating film 4 is formed and a portion where the ferroelectric 1 makes contact with the electrode 3, with an electron emitting window formed in the portion where they make contact. Electron emission by the polarization reversal of the ferroelectric is known to start to occur from an applied pulse voltage that is about twice the resisting electric field of the ferroelectric or greater. Thus when a driving pulse voltage 6 is applied to the electrode 3, an effective voltage applied to the ferroelectric 1 during drive is lowered enough under wiring where the ferroelectric 1 and the film 4 form double layers, so that electron emission is not started, while electron emission can be effected only from the electron emitting window.



(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号

特開平10－27539

(43)公開日　平成10年(1998) 1月27日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ		技術表示箇所
Ｈ０１Ｊ　1/30			Ｈ０１Ｊ　1/30		Ａ
Ｇ０９Ｇ　3/22		4237－5H	Ｇ０９Ｇ　3/22		

審査請求　未請求　請求項の数６　ＯＬ　（全 6 頁）

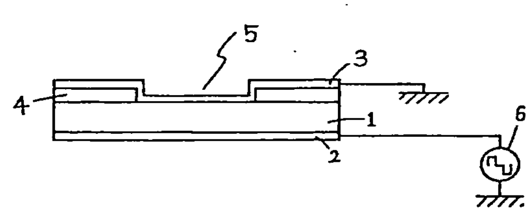
(21)出願番号　特願平8－180377

(22)出願日　平成８年(1996) ７月10日

(71)出願人　000005049
シャープ株式会社
大阪府大阪市阿倍野区長池町22番22号
(72)発明者　大谷　昇
大阪府大阪市阿倍野区長池町22番22号　シャープ株式会社内
(74)代理人　弁理士　梅田　勝

(54)【発明の名称】　強誘電体冷陰極及びその駆動方法

(57)【要約】
【課題】　本発明は、放出電子の放出面積や放出量等の制御や放出電子の広がりの抑制が可能で、低電圧駆動の強誘電体冷陰極及びその駆動方法を提供することを目的としている。
【解決手段】　強誘電体１が下部電極２と上部電極３とに挟持されて構成される強誘電体冷陰極において、強誘電体１と上部電極３との間に絶縁膜４を介する部分と、強誘電体１と上部電極３とが接して電子放出窓５を成す部分とを備えて構成する。



【特許請求の範囲】

【請求項１】 強誘電体が下部電極と上部電極とに挟持されて構成される強誘電体冷陰極において、
強誘電体と上部電極との間に絶縁膜を介する部分と、強誘電体と上部電極とが接して電子放出窓を成す部分とを備えたことを特徴とする強誘電体冷陰極。

【請求項２】 強誘電体が下部電極と上部電極とに挟持されて構成される強誘電体冷陰極において、
上部電極として第１の上部電極と第２の上部電極を備え、強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分と、強誘電体と第１の上部電極とが接して電子放出窓を成す部分とを備え、前記強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分の第１の電極上に第２の絶縁膜を介して第２の上部電極を設けたことを特徴とする強誘電体冷陰極。

【請求項３】 強誘電体が下部電極と上部電極とに挟持されて構成される強誘電体冷陰極において、
上部電極として第１の上部電極と第２の上部電極と第３の上部電極とを備え、強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分と、強誘電体と第１の上部電極とが接して電子放出窓を成す部分とを備え、前記強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分の第１の電極上に第２の絶縁膜を介して第２の上部電極を設け、更に該第２の上部電極上に第２の絶縁膜を介して第３の上部電極を設けたことを特徴とする強誘電体冷陰極。

【請求項４】 請求項１から３のいずれか１項に記載の強誘電体冷陰極において、前記絶縁膜の誘電率が１００以上であることを特徴とする強誘電体冷陰極。

【請求項５】 請求項２に記載の強誘電体冷陰極の駆動方法であって、前記第２の上部電極に正の電界を印加することを特徴とする強誘電体冷陰極の駆動方法。

【請求項６】 請求項３に記載の強誘電体冷陰極の駆動方法であって、前記第２の上部電極に正の電界を印加し、前記第３の上部電極に負の電界を印加することを特徴とする強誘電体冷陰極の駆動方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、印刷装置等の画像形成装置や平面ディスプレイなどに応用される電子を放出する強誘電体冷陰極及びその駆動方法に関するものである。

【０００２】

【従来の技術】従来より、Ｐｂ（Ｚｒ，Ｔｉ）O_3（以下ＰＺＴと称す）や（Ｐｂ，Ｌａ）（Ｚｒ，Ｔｉ）O_3（以下ＰＬＺＴと称す）などの強誘電体は、自発分極を有する材料であり、高速パルス印加による分極反転によって、数Ａ／ｃm^2以上の放出電流密度が得られることが知られている。

【０００３】ここで、従来の電子ビームを放出する強誘電体冷陰極として、H.Gundel等により報告されているものについて、その概略構成図である図５を用いて説明する（J.Appl.Phys.69(2),pp975,1991参照）。図５に示すように、この強誘電体冷陰極は、強誘電体１０１が下部電極１０２と上部櫛形電極１０３とによって挟持された構造である。下部電極１０２と上部櫛形電極１０３との間に交番電界１０６を印加すると、強誘電体１０１内部に印加された電界を打ち消すような向きに分極が生じ、この分極が印加交番電界１０６の変化に伴って反転され、強電界が生じる。そして、強誘電体１０１に対して１$0^7$Ｖ／ｃm^2以上の強電界を印加すると、強誘電体１０１の電子が上部櫛形電極１０３により引き出され外界に放出される。

【０００４】上記の強誘電体冷陰極は、素子構造が簡単であり、比較的低真空（１$0^{-1}$ｍＴｏｒｒ以上）でも電子放出が可能であることから、印刷装置等の画像形成装置や平面ディスプレイへの応用が提案されている。

【０００５】

【発明が解決しようとする課題】しかしながら、上記の従来の強誘電体冷陰極では、強誘電体上に直接金属配線を形成して動作させると、配線下の強誘電体全体で反転し電子放出が起こり、電子放出部を限定することができないため、電子放出面積及び電子放出量を制御することができなかった。さらに、例えばディスプレイへ応用したような場合には、配線電極下の強誘電体での分極反転により発生した電子放出のために、配線部の電子放出による蛍光体発光が生じ、表示品質の低下を招くという問題があった。また、印刷装置等の画像形成装置に応用したものの場合でも、潜像形成において同様のような問題が発生した。

【０００６】このような問題は、強誘電体を加工して配線すれば回避できる。しかしながら、ＰＺＴ等の複合金属酸化物は、ＲＩＥ等のドライエッチングが困難であること、加工エッジ部分での漏れ電流の増大すること、プロセスの複雑化等の別の問題が発生した。

【０００７】また、ＰＺＴセラミックスを利用した強誘電体冷陰極の場合、電子放出を得るためのパルス電圧は１５０～３００Ｖと高く、デバイス応用のためには駆動電圧の低減が必要である。

【０００８】また、強誘電体冷陰極からの電子放出は、強誘電体及び電極表面の散乱による広がり角があり、この放出電子の広がりを抑制できないために、平面ディスプレイ応用等での高画質を得ることができなかった。

【０００９】本発明は、上記のような課題を解決するためになされたものであって、放出電子の放出面積や放出量等の制御や放出電子の広がりの抑制が可能で、低電圧駆動の強誘電体冷陰極及びその駆動方法を提供することを目的としている。

【００１０】

【課題を解決するための手段】上記課題を解決するた

め、本発明では、強誘電体が下部電極と上部電極とに挟持されて構成される強誘電体冷陰極において、強誘電体と上部電極との間に絶縁膜を介する部分と、強誘電体と上部電極とが接して電子放出窓を成す部分とを備えて構成している。

【００１１】また、本発明では、強誘電体が下部電極と上部電極とに挟持されて構成される強誘電体冷陰極において、上部電極として第１の上部電極と第２の上部電極を備え、強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分と、強誘電体と第１の上部電極とが接して電子放出窓を成す部分とを備え、強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分の第１の電極上に第２の絶縁膜を介して第２の上部電極を設けて構成している。

【００１２】また、本発明では、強誘電体が下部電極と上部電極とに挟持されて構成される強誘電体冷陰極において、上部電極として第１の上部電極と第２の上部電極と第３の上部電極とを備え、強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分と、強誘電体と第１の上部電極とが接して電子放出窓を成す部分とを備え、前記強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分の第１の電極上に第２の絶縁膜を介して第２の上部電極を設け、更に該第２の上部電極上に第２の絶縁膜を介して第３の上部電極を設けて構成している。

【００１３】さらに、本発明では、上記の強誘電体冷陰極において、絶縁膜の誘電率を１００以上としている。

【００１４】また、本発明では、強誘電体が下部電極と上部電極とに挟持されて構成される強誘電体冷陰極において、上部電極として第１の上部電極と第２の上部電極を備え、強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分と、強誘電体と第１の上部電極とが接して電子放出窓を成す部分とを備え、強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分の第１の電極上に第２の絶縁膜を介して第２の上部電極を設けて構成した強誘電体冷陰極の駆動方法として、第２の上部電極に正の電界を印加することとしている。

【００１５】また、本発明では、強誘電体が下部電極と上部電極とに挟持されて構成される強誘電体冷陰極において、上部電極として第１の上部電極と第２の上部電極と第３の上部電極とを備え、強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分と、強誘電体と第１の上部電極とが接して電子放出窓を成す部分とを備え、前記強誘電体と第１の上部電極との間に第１の絶縁膜を介する部分の第１の電極上に第２の絶縁膜を介して第２の上部電極を設け、更に該第２の上部電極上に第２の絶縁膜を介して第３の上部電極を設けて構成した強誘電体冷陰極の駆動方法として、第２の上部電極に正の電界を印加し、第３の上部電極に負の電界を印加することとしている。

【００１６】本発明によれば、強誘電体上に電子放出窓を備えた構成としているので、電子放出を電子放出窓部だけに限定することができ、強誘電体上に直接形成されていない配線金属下の強誘電体において分極反転が発生せず、配線下からの電子放出は起こらない。これにより、電子放出面積及び電子放出量を制御することが可能となる。従って、例えばディスプレイ応用の場合、発光部以外の蛍光体への電子放出によって発光することを防止でき、表示品質を向上させることができ、このことは印刷装置等の画像形成装置においても同様の作用を奏する。

【００１７】また、第２の上部電極により電子引き出し電界を印加することにより、強誘電体からの電子放出電圧を低減することができ、素子の駆動電圧の低減が可能となる。さらに、電子引き出し電界強度を変化させれば、同一パルス電圧での電子放出量を制御することができる。

【００１８】また、第３の上部電極に負の電界を印加することにより、放出電子の広がりを抑制することができ、高画質の平面ディスプレイや、転写精度に優れた印刷装置等の画像形成装置を実現することが可能となる。

【００１９】

【発明の実施の形態】以下、本発明の実施の形態について、図面を参照して説明する。本発明の強誘電体冷陰極は複数の冷陰極の集合体により構成されるものであるが、以下では単一の素子構造を示す図を用いる。

【００２０】図１は、本発明の第１の実施形態の強誘電体冷陰極の概略断面図である。図１に示すように、この強誘電体冷陰極は、強誘電体１の下部、上部のそれぞれに下部電極２、上部電極３が配置され、そして強誘電体１と上部電極３との間に絶縁膜４が形成されている部分と、強誘電体１と上部電極３とが接する部分があり、強誘電体１と上部電極３とが接する部分により電子放出窓が構成されている。なお、図１は強誘電体冷陰極の断面構造を示したものであるが、実際には、絶縁膜４及び上部電極３が電子放出窓周囲を囲むように形成されているものである。

【００２１】強誘電体の分極反転による電子放出は、強誘電体の抗電界のほぼ２倍以上の印加パルス電圧から起こり始めることが知られている。したがって、この第１の実施形態の強誘電体冷陰極において、上部電極３に駆動パルス電圧６を印加すると、強誘電体１と絶縁膜４との２重層となっている配線下、即ち強誘電体１と上部電極３との間に絶縁膜４が形成されている部分では、駆動時に強誘電体１にかかる実効電圧が低下し電子放出に至らず、電子放出窓のみからの電子放出を行うことができる。

【００２２】次に、第２の実施形態として、図２に示すように、上記第１の強誘電体冷陰極の上部電極３上に第２の絶縁膜１４を介して第２の上部電極１３を設けたものについて説明する。なお、図２も強誘電体冷陰極の断

面構造を示したものであるが、実際には、絶縁膜４、上部電極３、第２の絶縁膜１４、及び第２の上部電極１３が電子放出窓周囲を囲むように形成されているものである。

【００２３】この第２の実施形態の強誘電体冷陰極の第２の上部電極１３に、正のバイアス電界７を印加すると、この第２の上部電極１３が電子引き出し電極として作用し、電子放出量を増大させることができる。また、駆動パルス電圧６を低減しても、上記第１の実施形態のものとほぼ同じ電子放出量を得ることができ、駆動電圧の低減を図ることもできる。さらに、駆動パルス電圧６を一定とし、第２の上部電極１３へ印加する正のバイアス電界７を制御することにより、電子放出量の制御を行うことが可能となる。

【００２４】次に、第３の実施形態として、図３に示すように、上記第２の強誘電体冷陰極の第２の上部電極１３上に第３の絶縁膜２４を介して第３の上部電極２３を設けたものについて説明する。なお、図３も強誘電体冷陰極の断面構造を示したものであるが、実際には、絶縁膜４、上部電極３、第２の絶縁膜１４、第２の上部電極１３、第３の絶縁膜２４、及び第３の上部電極２３が電子放出窓周囲を囲むように形成されているものである。

【００２５】この第３の実施形態の強誘電体冷陰極の第３の上部電極２３に、負のバイアス電界８を印加すると、この第３の上部電極２３が静電レンズとして作用し、放出電子の広がりを制御することが可能となる。

【００２６】なお、上記の第１～３の実施形態において、絶縁膜４としては、SiO_2やSiN等の誘電体膜を用いることができるが、これらの誘電体膜は誘電率が比較的に低い（例えばSiO_2が４程度）。これに対して、強誘電体１の誘電率は一般に高く（例えばＰＺＴが１０００程度）、強誘電体１と絶縁膜４とが積層された部分での強誘電体の実効電圧を１／２とするには、絶縁膜厚として数ｎｍの厚さが要求される。例えば、SiO_2とＰＺＴとの組み合わせでは、１μｍ厚のＰＺＴ膜に対しSiO_2膜厚が４ｎｍとなってしまうが、このような極薄膜で強誘電体上に耐圧及び耐リーク性に優れたものを形成するのは困難である。したがって、絶縁膜４としては、誘電率が１００以上の高誘電体膜が望ましく、具体的な材料としては$SrTiO_3$や$BaSrTiO_3$等が挙げられる。

【００２７】また、上記第１～３の実施形態の強誘電体冷陰極の強誘電体１としては、ＰＺＴ，ＰＬＺＴ，$SrBi_2Ta_2O_9$，$BaTiO_3$などの複合金属酸化物により構成することができる。また、上部電極３，１３，２３には、Ｐｔ，Ａｕ，Ａｌ等の金属材料を用いることができる。

【００２８】

【実施例】以下、本発明のより具体的な実施例について、図面を参照して説明する。まず、第１の実施例として、上記第２の実施形態（図２参照）の強誘電体１としてＰＺＴ強誘電体膜を用いたものについて、その製造方法から説明する。

【００２９】Ｓｉ基板表面に熱酸化SiO_2形成し、その上にＲＦスパッタ法により膜厚１０ｎｍのＴｉ薄膜と下部電極２である膜厚２００ｎｍのＰｔ電極膜とを順次形成した。

【００３０】そして、この基板上に、ゾルゲル法により、スピン塗布（３０００ｒｐｍ×２０秒）、仮焼成（４００℃×３０分）、本焼成（６５０℃×２０秒）をそれぞれ順次繰り返し、約８００ｎｍの強誘電体１であるＰＺＴ強誘電体膜を形成した。

【００３１】その後、絶縁膜４として$SrTiO_3$膜を採用し、ＲＦスパッタ法により基板温度４００℃、ＲＦスパッタパワー２００Ｗ、スパッタガスに酸素１００％を用い、ガス圧２ｍＴｏｒｒという条件で、膜厚約５０ｎｍのものを形成した。それから、電子放出窓５を形成するために、$SrTiO_3$膜のパターニングを行った。このパターニングは、通常のフォトリソグラフィ、ウエットエッチング（エッチング液：塩酸（ＨＣｌ）とバッファードフッ素（ＢＨＦ）と水との混合液）により、２ｍｍ×２ｍｍの窓を形成したものである。

【００３２】このようにして形成した絶縁膜４上に、上部電極３として膜厚５０ｎｍのＰｔ膜をＥＢ蒸着法により形成し、次いで、第２の絶縁膜１４として膜厚３００ｎｍのSiO_2膜をＲＦスパッタ法により形成した。そして、電子放出窓５を形成するため、上記と同様に、フォトリソグラフィ、ウエットエッチング（エッチング液：ＢＨＦ）により、SiO_2膜のパターニングを行った。

【００３３】さらに、この第２の絶縁膜１４上に、フォトレジストをマスクとしたリフトオフ法により、膜厚２００ｎｍのＰｔ膜をＥＢ蒸着法を用いて成膜し、電子放出窓５を有するように第２の上部電極１３を形成し、本実施例の強誘電体冷陰極の作製を完了した。

【００３４】次に、上記のようにして作製した強誘電体冷陰極の電気特性の評価について、説明する。本実施例の強誘電体冷陰極を真空槽中に配置し、10^{-5}Ｔｏｒｒまで排気し、コレクターとしてＰｔ板と蛍光板を用いて、素子駆動を行った。その駆動は、図２に示すように、上部電極３をグランドに接地し、下部電極２に０から２０Ｖの正のバイアス電圧（駆動パルス電圧６）を印加した。このときに、蛍光板での蛍光体発光による発光パターンの評価を行った結果、電子放出窓５以外に輝点は見られず、配線下の電子放出が抑止されていることが確認された。

【００３５】次いで、電子放出特性及びバイアス電界（正のバイアス電界７）による電子放出特性の依存性を測定した結果を図４に示す。図４から、第２の上部電極１３への正のバイアス電界７の増加と伴い、電子放出開

始電圧が低下していることがわかる。また、以上の結果から、駆動電圧を一定とすれば、第２の上部電極１３への正のバイアス電界７により電子放出量を制御可能であることが判る。

【００３６】なお、上記第１の実施例において、下部電極２が素子全面に形成されているが、本発明はこれに限定されるものではなく、駆動素子を選択するためのストライプ状電極にするなど、実際の応用デバイスに応じて適宜設計自由なものである。

【００３７】次に、上記第３の実施形態に対応する第２の実施例として、上記第１の実施例の第２の上部電極１３上に、上記第１の実施例と同様にして、ＳｉO_2膜から成る第３の絶縁層２４とＰｔ膜から成る第３の上部電極２３とを順次形成した第２の実施例について説明する。

【００３８】この第２の実施例の強誘電体冷陰極について、図３に示すように、第３の上部電極２３に－２０～０Ｖの負のバイアス電界８を印加し、その他は上記第１の実施例と同様に電気的接続を行った同様の方法で、電気特性の評価を行った。ただし、ここで、アノードには蛍光板を用いた。その評価の結果、蛍光板での蛍光体発光パターンは、第３の上部電極２３への負のバイアス電界８の印加電圧を、負方向に上げる（０Ｖから－２０Ｖへと下げていく）ことにより、放出電子が収束する様子が観察され、静電レンズとして作用するレンズ効果が確認された。

【００３９】

【発明の効果】以上のように、本発明によれば、強誘電体冷陰極による電子放出領域は電子放出窓だけに限定され、強誘電体上に直接形成されていない配線金属下での強誘電体の分極反転が発生していないので、配線下からの電子放出は起こらない。これにより、放出電子量制御性に優れた強誘電体冷陰極を実現することができる。

【００４０】また、強誘電体を加工することなく平面構造の強誘電体エミッタを形成することができ、冷陰極作製プロセスを簡略化することができる。

【００４１】したがって、本発明の強誘電体冷陰極を用いれば、発光部分以外の蛍光体への電子放出によって発生していた表示品質の低下がない高品質な平面ディスプレイや、転写精度に優れた印刷装置等の画像形成装置を実現することが可能となる。

【００４２】さらに、本発明によれば、電子引き出し電界印加電極として、第２の上部電極を設けることにより、強誘電体からの電子放出のために印加するパルス電圧を低減することができ、素子の駆動電圧の低減を図ることができる。また、電子引き出し電界強度、即ち第２の上部電極への印加電界強度を変化させることにより、同一パスル電圧での電子放出量を制御することが可能となる。

【００４３】さらに、本発明によれば、第３の上部電極を設けることにより、放出電子の広がりを抑制することができ、高画質な平面ディスプレイや転写精度に優れた印刷装置等の画像形成装置を実現することが可能となる。

【図面の簡単な説明】

【図１】本発明による第１の実施形態の概略構造を示す要部断面図である。

【図２】本発明による第２の実施形態の概略構造を示す要部断面図である。

【図３】本発明による第３の実施形態の概略構造を示す要部断面図である。

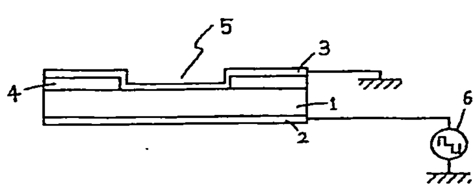
【図４】第２の実施形態に対応する第１の実施例の電子放出特性及び第２の上部電極に印加するバイアス電界による電子放出特性の依存性を測定した結果を示す図である。

【図５】従来の強誘電体冷陰極の概略構造を示す要部断面図である。

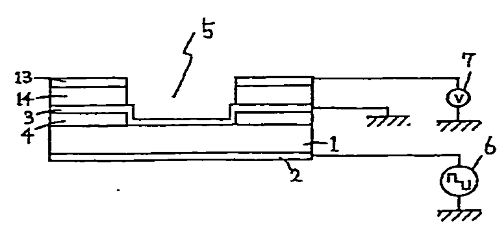
【符号の説明】

１　強誘電体
２　下部電極
３，１３，２３　上部電極
４，１４，２４　絶縁層
５　電子放出窓
６　駆動パルス電圧
７　正のバイアス電界
８　負のバイアス電界

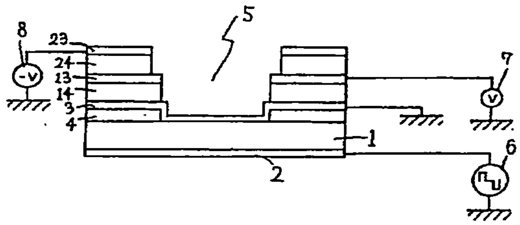
【図１】



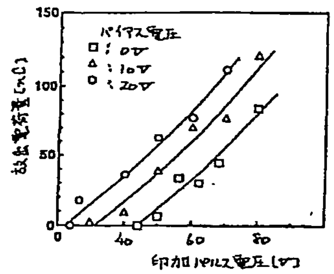
【図２】



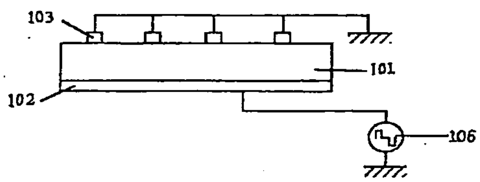
【図3】


5
8
23
24
13
14
3
4
1
2
7
6
-V
V

【図4】


150
100
50
0
0
40
60
80
バイアス電圧
□：0V
△：10V
○：20V
印加パルス電圧[V]

【図5】


103
101
102
106

JAPANESE [JP,10-027539,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS EXAMPLE DESCRIPTION OF DRAWINGS DRAWINGS

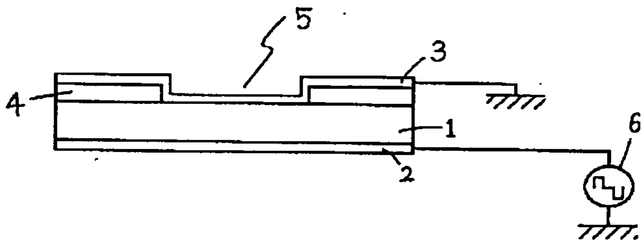
[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] Ferroelectric cold cathode characterized by having the part which the part which minds an insulator layer between a ferroelectric and an up electrode, and a ferroelectric and an up electrode touch in the ferroelectric cold cathode from which a ferroelectric is pinched and constituted by a lower electrode and the up electrode, and accomplishes an electron emission aperture.
[Claim 2] In the ferroelectric cold cathode from which a ferroelectric is pinched and constituted by a lower electrode and the up electrode The part which is equipped with the 1st up electrode and the 2nd up electrode as an up electrode, and minds the 1st insulator layer between a ferroelectric and the 1st up electrode, Ferroelectric cold cathode characterized by preparing the 2nd up electrode through the 2nd insulator layer on the 1st [of the part which is equipped with the part which a ferroelectric and the 1st up electrode touch and accomplishes an electron emission aperture, and minds the 1st insulator layer between said ferroelectric and the 1st up electrode] electrode.
[Claim 3] In the ferroelectric cold cathode from which a ferroelectric is pinched and constituted by a lower electrode and the up electrode The part which is equipped with the 1st up electrode, the 2nd up electrode, and the 3rd up electrode as an up electrode, and minds the 1st insulator layer between a ferroelectric and the 1st up electrode, It has the part which a ferroelectric and the 1st up electrode touch and accomplishes an electron emission aperture. a 1st [of the part which minds the 1st insulator layer between said ferroelectric and the 1st up electrode] electrode top -- the 2nd insulator layer -- minding -- the 2nd up electrode -- preparing -- further -- this -- the ferroelectric cold cathode characterized by preparing the 3rd up electrode through the 2nd insulator layer on the 2nd up electrode.
[Claim 4] Ferroelectric cold cathode characterized by the dielectric constant of said insulator layer being 100 or more in ferroelectric cold cathode given in any 1 term of claims 1-3.
[Claim 5] The drive approach of the ferroelectric cold cathode which is the drive approach of ferroelectric cold cathode according to claim 2, and is characterized by impressing forward electric field to said 2nd up electrode.
[Claim 6] The drive approach of the ferroelectric cold cathode characterized by being the drive approach of ferroelectric cold cathode according to claim 3, impressing forward electric field to said 2nd up electrode, and impressing negative electric field to said 3rd up electrode.

[Translation done.]

Drawing selection Representative drawing



[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the ferroelectric cold cathode which emits the electron applied to image formation equipments, flat-surface displays, etc., such as an airline printer, and its drive approach.
[0002]
[Description of the Prior Art] Conventionally, ferroelectrics, such as Pb(Zr, Ti) O3 (Following PZT is called) and O (Zr (Pb, La), Ti) 3 (Following PLZT is called), are ingredients which have spontaneous polarization, and it is known by the polarization reversal by high-speed pulse impression that a two or more several A/cm emission current consistency will be obtained.
[0003] Here, what is reported by H.Gundel etc. is explained as ferroelectric cold cathode which emits the conventional electron beam using drawing 5 which is the outline block diagram (J. Appl.Phys.69(2), pp975, 1991 reference). As shown in drawing 5 , this ferroelectric cold cathode is the structure where the ferroelectric 101 was pinched with the lower electrode 102 and the up Kushigata electrode 103. If an alternating electric field 106 is impressed between the lower electrode 102 and the up Kushigata electrode 103, polarization arises in sense which negates the electric field impressed to the ferroelectric 101 interior, this polarization will be reversed with change of the impression alternating electric field 106, and strong electric field will arise. And if two or more 107 V/cm strong electric field are impressed to a ferroelectric 101, the electron of a ferroelectric 101 will be drawn out by the up Kushigata electrode 103, and will be emitted to the external world.
[0004] The above-mentioned ferroelectric cold cathode is simple for component structure, and comparatively, also by the low vacuum (10 to 1 or more mTorrs), since electron emission is possible, the application to image formation equipments and flat-surface displays, such as an airline printer, is proposed.
[0005]
[Problem(s) to be Solved by the Invention] However, if direct metal wiring was formed on a ferroelectric and it was made to operate, since it could not be reversed with the whole ferroelectric under wiring, electron emission was not able to happen and the electron emission section was not able to be limited, electron emission area and the amount of electron emission were uncontrollable by the above-mentioned conventional ferroelectric cold cathode. Furthermore, when it applied, for example to a display, fluorescent substance luminescence by the electron emission of the wiring section arose for the electron emission generated by polarization reversal with the ferroelectric under a wiring electrode, and there was a problem of causing deterioration of display quality. Moreover, although applied to image formation equipments, such as an airline printer, in latent-image formation, a problem which is the same occurred also in the case.
[0006] Such a problem is avoidable, if a ferroelectric is processed and it wires. However, another problems, such as complication of that dry etching, such as RIE, is difficult, that the leakage current in a processing edge part increases, and a process, generated compound metallic oxides, such as PZT.
[0007] Moreover, in the case of the ferroelectric cold cathode using PZT ceramics, the pulse voltage for obtaining electron emission is as high as 150-300V, and needs reduction of driver voltage for device application.
[0008] Moreover, the electron emission from ferroelectric cold cathode had a ferroelectric and an angle of divergence by dispersion of an electrode surface, and since breadth of this emission electron was not able to be controlled, high definition in flat-surface display application etc. was not able to be obtained.
[0009] This invention is made in order to solve the above technical problems, and control of the emission area of the emission electron, a burst size, etc. and control of the breadth of the emission electron are possible, and it aims at offering the ferroelectric cold cathode and its drive approach of a low-battery drive.
[0010]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, in the ferroelectric cold cathode from which a ferroelectric is pinched and constituted by a lower electrode and the up electrode, the part which the part which minds an insulator layer between a ferroelectric and an up electrode, and a ferroelectric and an

up electrode touch, and accomplishes an electron emission aperture has and consists of this inventions.
[0011] Moreover, it sets to the ferroelectric cold cathode from which a ferroelectric is pinched and constituted from this invention by a lower electrode and the up electrode. The part which is equipped with the 1st up electrode and the 2nd up electrode as an up electrode, and minds the 1st insulator layer between a ferroelectric and the 1st up electrode, It has the part which a ferroelectric and the 1st up electrode touch and accomplishes an electron emission aperture, and the 2nd up electrode is prepared and constituted through the 2nd insulator layer on the 1st [of the part which minds the 1st insulator layer between a ferroelectric and the 1st up electrode] electrode.
[0012] Moreover, it sets to the ferroelectric cold cathode from which a ferroelectric is pinched and constituted from this invention by a lower electrode and the up electrode. The part which is equipped with the 1st up electrode, the 2nd up electrode, and the 3rd up electrode as an up electrode, and minds the 1st insulator layer between a ferroelectric and the 1st up electrode, It has the part which a ferroelectric and the 1st up electrode touch and accomplishes an electron emission aperture. a 1st [of the part which minds the 1st insulator layer between said ferroelectric and the 1st up electrode] electrode top -- the 2nd insulator layer -- minding -- the 2nd up electrode -- preparing -- further -- this -- the 3rd up electrode is prepared and constituted through the 2nd insulator layer on the 2nd up electrode.
[0013] Furthermore, in this invention, the dielectric constant of an insulator layer is made or more into 100 in the above-mentioned ferroelectric cold cathode.
[0014] Moreover, it sets to the ferroelectric cold cathode from which a ferroelectric is pinched and constituted from this invention by a lower electrode and the up electrode. The part which is equipped with the 1st up electrode and the 2nd up electrode as an up electrode, and minds the 1st insulator layer between a ferroelectric and the 1st up electrode, It has the part which a ferroelectric and the 1st up electrode touch and accomplishes an electron emission aperture. It is supposed that forward electric field are impressed to the 2nd up electrode as the drive approach of the ferroelectric cold cathode which prepared and constituted the 2nd up electrode through the 2nd insulator layer on the 1st [of the part which minds the 1st insulator layer between a ferroelectric and the 1st up electrode] electrode.
[0015] Moreover, it sets to the ferroelectric cold cathode from which a ferroelectric is pinched and constituted from this invention by a lower electrode and the up electrode. The part which is equipped with the 1st up electrode, the 2nd up electrode, and the 3rd up electrode as an up electrode, and minds the 1st insulator layer between a ferroelectric and the 1st up electrode, It has the part which a ferroelectric and the 1st up electrode touch and accomplishes an electron emission aperture. The 2nd up electrode is prepared through the 2nd insulator layer on the 1st [of the part which minds the 1st insulator layer between said ferroelectric and the 1st up electrode] electrode. furthermore -- this -- it is supposed that forward electric field are impressed to the 2nd up electrode as the drive approach of the ferroelectric cold cathode which prepared and constituted the 3rd up electrode through the 2nd insulator layer on the 2nd up electrode, and negative electric field are impressed to the 3rd up electrode.
[0016] Since it is considering as the configuration equipped with the electron emission aperture on the ferroelectric according to this invention, electron emission can be limited only to an electron emission window part, polarization reversal does not occur in the ferroelectric under the wiring metal which is not directly formed on the ferroelectric, and the electron emission from under wiring does not happen. This becomes possible to control electron emission area and the amount of electron emission. It follows, for example, in display application, it can prevent emitting light by the electron emission to fluorescent substances other than a light-emitting part, display quality can be raised, and this does the same operation so also in image formation equipments, such as an airline printer.
[0017] Moreover, by impressing electronic drawer electric field with the 2nd up electrode, the electron emission electrical potential difference from a ferroelectric can be reduced, and reduction of the driver voltage of a component is attained. Furthermore, if electronic drawer field strength is changed, the amount of electron emission in the same pulse voltage is controllable.
[0018] Moreover, by impressing negative electric field to the 3rd up electrode, the breadth of the emission electron can be controlled and it becomes possible to realize image formation equipments, such as a high-definition flat-surface display and an airline printer excellent in imprint precision.
[0019]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing. Although the ferroelectric cold cathode of this invention is constituted by the aggregate of two or more cold cathode, below, drawing showing single component structure is used.
[0020] Drawing 1 is the outline sectional view of the ferroelectric cold cathode of the 1st operation gestalt of this invention. As shown in drawing 1 , the lower electrode 2 and the up electrode 3 are arranged at each of the lower part of a ferroelectric 1, and the upper part, and this ferroelectric cold cathode has the part which the part by which the insulator layer 4 is formed between the ferroelectric 1 and the up electrode 3, and a ferroelectric 1 and the up electrode 3 touch, and the electron emission aperture is constituted by the part which a ferroelectric 1 and the up electrode 3 touch. In addition, in fact, although drawing 1 shows the cross-section structure of ferroelectric cold cathode, it is formed so that an insulator layer 4 and the up electrode 3 may surround the perimeter of an electron

emission aperture.

[0021] It is known that the electron emission by polarization reversal of a ferroelectric will begin to be generated by the coercive electric field twice [about / more than] the impression pulse voltage of a ferroelectric. Therefore, in the ferroelectric cold cathode of this 1st operation gestalt, if the driving pulse electrical potential difference 6 is impressed to the up electrode 3 In the part in which the insulator layer 4 is formed between the bottoms 3 of wiring used as the double layer of a ferroelectric 1 and an insulator layer 4, i.e., a ferroelectric 1 and an up electrode, the effective voltage built over a ferroelectric 1 at the time of a drive falls, and it does not result in electron emission, but electron emission only from an electron emission aperture can be performed.

[0022] Next, as 2nd operation gestalt, as shown in drawing 2 , what formed the 2nd up electrode 13 through the 2nd insulator layer 14 on the up electrode 3 of the ferroelectric cold cathode of the above 1st is explained. In addition, in fact, although drawing 2 also shows the cross-section structure of ferroelectric cold cathode, it is formed so that an insulator layer 4, the up electrode 3, the 2nd insulator layer 14, and the 2nd up electrode 13 may surround the perimeter of an electron emission aperture.

[0023] If the forward bias electric field 7 are impressed to the 2nd up electrode 13 of the ferroelectric cold cathode of this 2nd operation gestalt, this 2nd up electrode 13 can act as an electronic drawer electrode, and the amount of electron emission can be increased. Moreover, even if it reduces the driving pulse electrical potential difference 6, the almost same amount of electron emission as the thing of the operation gestalt of the above 1st can be obtained, and reduction of driver voltage can also be aimed at. Furthermore, it becomes possible to control the amount of electron emission by seting constant the driving pulse electrical potential difference 6, and controlling the forward bias electric field 7 impressed to the 2nd up electrode 13.

[0024] Next, as 3rd operation gestalt, as shown in drawing 3 , what formed the 3rd up electrode 23 through the 3rd insulator layer 24 on the 2nd [of the ferroelectric cold cathode of the above 2nd] up electrode 13 is explained. In addition, in fact, although drawing 3 also shows the cross-section structure of ferroelectric cold cathode, it is formed so that an insulator layer 4, the up electrode 3, the 2nd insulator layer 14, the 2nd up electrode 13, the 3rd insulator layer 24, and the 3rd up electrode 23 may surround the perimeter of an electron emission aperture.

[0025] If the negative bias electric field 8 are impressed to the 3rd up electrode 23 of the ferroelectric cold cathode of this 3rd operation gestalt, this 3rd up electrode 23 will act as an electrostatic lens, and it becomes possible to control the breadth of the emission electron.

[0026] In addition, in the 1-3rd above-mentioned operation gestalten, as an insulator layer 4, although dielectric films, such as SiO2 and SiN, can be used, it is low [these dielectric films] in [a dielectric constant] comparison (SiO2 is about four). On the other hand, in order for the dielectric constant of a ferroelectric 1 to set to one half effective voltage of the ferroelectric in the part to which the laminating of a ferroelectric 1 and the insulator layer 4 was carried out highly (PZT is about 1000) generally, the thickness of several nm is required as insulator layer thickness. For example, although SiO2 thickness will be set to 4nm to the PZT film of 1-micrometer thickness in the combination of SiO2 and PZT, it is difficult to form the thing excellent in pressure-proofing and leak-proof nature on a ferroelectric by such ultra-thin film. Therefore, as an insulator layer 4, 100 or more high dielectric films have a desirable dielectric constant, and SrTiO3 and BaSrTiO3 grade are mentioned as a concrete ingredient.

[0027] Moreover, as a ferroelectric 1 of the ferroelectric cold cathode of the operation gestalt of the above 1-3rds, compound metallic oxides, such as PZT, PLZT, SrBi2Ta2O9, and BaTiO3, can constitute. Moreover, metallic materials, such as Pt, Au, and aluminum, can be used for the up electrodes 3, 13, and 23.

[0028]

[Example] Hereafter, the more concrete example of this invention is explained with reference to a drawing. First, what used the PZT ferroelectric film as a ferroelectric 1 of the operation gestalt (refer to drawing 2) of the above 2nd is explained from the manufacture approach as the 1st example.

[0029] It formed in Si substrate front face thermal oxidation SiO2, and sequential formation of Ti thin film of 10nm of thickness and the Pt electrode layer of 200nm of thickness which is the lower electrode 2 was carried out by RF spatter on it.

[0030] And on this substrate, with the sol gel process, spin spreading (3000rpmx 20 seconds), temporary baking (400 degree-Cx 30 minutes), and book baking (650 degree-Cx 20 seconds) was repeated successively, respectively, and the PZT ferroelectric film which is about 800nm ferroelectric 1 was formed.

[0031] Then, SrTiO3 film was adopted as an insulator layer 4, 100% of oxygen was used for the substrate temperature of 400 degrees C, RF spatter power 200W, and sputtering gas by RF spatter, and the thing of about 50nm of thickness was formed on the conditions of gas pressure 2mTorr. And in order to form the electron emission aperture 5, patterning of SrTiO3 film was performed. This patterning forms a 2mmx2mm aperture by the usual photolithography and wet etching (etching reagent: mixed liquor of a hydrochloric acid (HCl), a buffered fluorine (BHF), and water).

[0032] Thus, on the formed insulator layer 4, Pt film of 50nm of thickness was formed with EB vacuum deposition as an up electrode 3, and, subsequently SiO2 film of 300nm of thickness was formed by RF spatter as the 2nd

insulator layer 14. And in order to form the electron emission aperture 5, a photolithography and wet etching (etching reagent: BHF) performed patterning of SiO2 film like the above.

[0033] Furthermore, on this 2nd insulator layer 14, by the lift-off method which used the photoresist as the mask, Pt film of 200nm of thickness was formed using EB vacuum deposition, the 2nd up electrode 13 was formed so that it might have the electron emission aperture 5, and production of the ferroelectric cold cathode of this example was completed.

[0034] Next, evaluation of the electrical property of the ferroelectric cold cathode produced as mentioned above is explained. The ferroelectric cold cathode of this example has been arranged in a vacuum tub, it exhausted to 10-5Torr, and the component drive was performed, using Pt plate and a fluorescent screen as a collector. As shown in drawing 2 , the drive grounded the up electrode 3 to the gland, and impressed the forward bias voltage (driving pulse electrical potential difference 6) of 20V to the lower electrode 2 from 0. As a result of evaluating the luminescence pattern by fluorescent substance luminescence with a fluorescent screen at this time, the luminescent spot was not seen other than electron emission aperture 5, but it was checked that the electron emission under wiring is inhibited.

[0035] Subsequently, the result of having measured the dependency of the electron emission characteristic and the electron emission characteristic by bias electric field (forward bias electric field 7) is shown in drawing 4 . It turns out that it follows with the increment in the forward bias electric field 7 from drawing 4 to the 2nd up electrode 13, and electron emission starting potential is falling. Moreover, driver voltage is understood are fixed, then controllable in the amount of electron emission from the above result by the forward bias electric field 7 to the 2nd up electrode 13.

[0036] in addition, an actual application device, such as this invention not being limited to this and using it as the stripe-like electrode for choosing a driver element in the 1st example of the above, although the lower electrode 2 is formed all over the component, -- responding -- suitably -- a design -- it is free.

[0037] Next, the 2nd example which carried out sequential formation of the 3rd insulating layer 24 which consists of SiO2 film like the 1st example of the above on the 2nd [of the 1st example of the above] up electrode 13 as the 2nd example corresponding to the operation gestalt of the above 3rd, and the 3rd up electrode 23 which consists of Pt film is explained.

[0038] About the ferroelectric cold cathode of this 2nd example, as shown in drawing 3 , the negative bias electric field 8 of -20-0V were impressed to the 3rd up electrode 23, and others are the same approaches which performed electrical installation like the 1st example of the above, and evaluated the electrical property. However, the fluorescent screen was used for the anode here. As a result of the evaluation, signs that it was completed by the emission electron were observed by what the fluorescent substance luminescence pattern in a fluorescent screen raises the applied voltage of the negative bias electric field 8 to the 3rd up electrode 23 in the negative direction for (it lowers from 0V to -20V), and the lens effectiveness of acting as an electrostatic lens was checked.

[0039]

[Effect of the Invention] As mentioned above, since polarization reversal of the ferroelectric under the wiring metal which the electron emission field by ferroelectric cold cathode is limited only to an electron emission aperture, and is not directly formed on the ferroelectric has not occurred according to this invention, the electron emission from under wiring does not happen. Thereby, the ferroelectric cold cathode excellent in the amount controllability of emission electron is realizable.

[0040] Moreover, the ferroelectric emitter of the planar structure can be formed without processing a ferroelectric, and a cold cathode production process can be simplified.

[0041] Therefore, if the ferroelectric cold cathode of this invention is used, it will become possible to realize image formation equipments, such as a quality flat-surface display without deterioration of the display quality generated by the electron emission to fluorescent substances other than a light-emitting part part, and an airline printer excellent in imprint precision.

[0042] Furthermore, as an electronic drawer electric-field impression electrode, by preparing the 2nd up electrode, the pulse voltage impressed for the electron emission from a ferroelectric can be reduced, and, according to this invention, reduction of the driver voltage of a component can be aimed at. Moreover, it becomes possible by changing electronic drawer field strength, i.e., the impression field strength to the 2nd up electrode, to control the amount of electron emission in the same PASURU electrical potential difference.

[0043] Furthermore, according to this invention, by preparing the 3rd up electrode, the breadth of the emission electron can be controlled and it becomes possible to realize image formation equipments, such as an airline printer excellent in a high definition flat-surface display or imprint precision.

[Translation done.]

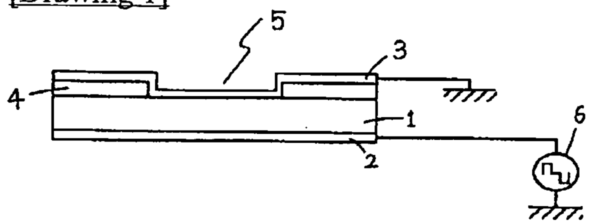
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the important section sectional view showing the outline structure of the 1st operation gestalt by this invention.
[Drawing 2] It is the important section sectional view showing the outline structure of the 2nd operation gestalt by this invention.
[Drawing 3] It is the important section sectional view showing the outline structure of the 3rd operation gestalt by this invention.
[Drawing 4] It is drawing showing the result of having measured the dependency of the electron emission characteristic by the bias electric field impressed to the electron emission characteristic of the 1st example and the 2nd up electrode corresponding to the 2nd operation gestalt.
[Drawing 5] It is the important section sectional view showing the outline structure of the conventional ferroelectric cold cathode.
[Description of Notations]
1 Ferroelectric
2 Lower Electrode
3, 13, 23 Up electrode
4, 14, 24 Insulating layer
5 Electron Emission Aperture
6 Driving Pulse Electrical Potential Difference
7 Forward Bias Electric Field
8 Negative Bias Electric Field

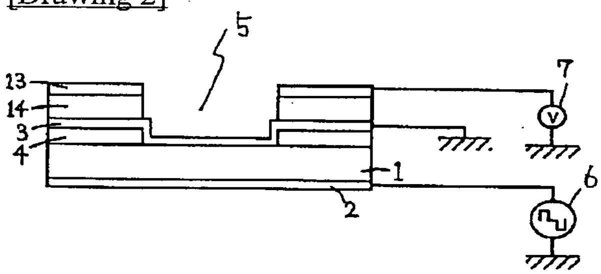
[Translation done.]

DRAWINGS

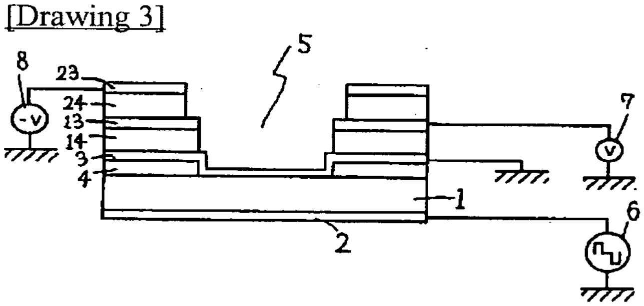
[Drawing 1]



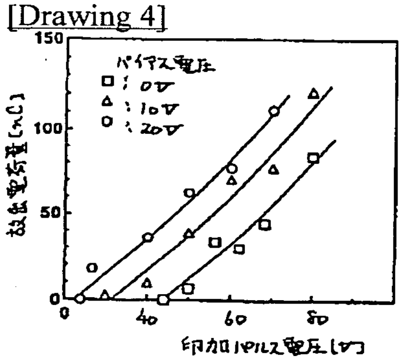
[Drawing 2]



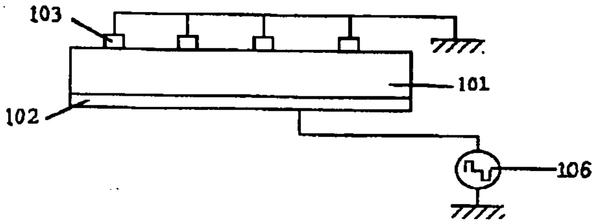
[Drawing 3]



[Drawing 4]



[Drawing 5]



[Translation done.]